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AQUATIC PLANT/MICROBIAL FILTERS FOR TREATING SEPTIC TANK EFFLUENT

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ABSTRACT

The use of natural biological processes for treating many types of wastewater have been developed by NASA at the John C. Stennis Space Center, NSTL, Mississippi, during the past 15 years. The simplest form of this technology involves the use of aquatic plant/marsh filters for treatment of septic tank effluent. Septic tank effluent from single home units can be treated to advanced secondary levels and beyond by using a 37.2 m^2 (400 ft^2) surface area washed gravel filter. This filter is generally 0.3 m (1 ft) deep with a surface cover of approximately 0.15 m (6 in) of gravel. The plants in this filter are usually aesthetic or ornamental such as calla lily (Zantedeschia aethiopica), canna lily (Canna flaccida), elephant ear (Colocasia esculenta), and water iris (Iris pseudacorus).

INTRODUCTION

Septic tank systems which serve approximately 25 percent of the U. S. population are installed in a variety of soil types and temperature ranges throughout the country.

A primary concern of many septic tank owners is odor. Many times odors are emitted from the house roof vents which are directly connected to the septic tank. This not only produces foul odors but also allows flies and other insects to breed in the tank, causing a nuisance and potential health problems. To avoid this problem, the inlet tee inside the septic tank should be capped or the tank constructed using an ell. Unfortunately, some septic tank installers still leave open tees entering the tanks. Open tees should be installed only at the effluent discharge point inside the tank to allow trapped gases to escape into the leach field or aquatic plant/microbial filter. Odors are also created when clogging of the leach field causes surface pooling of septic tank effluent before complete treatment has occurred.

Although some reduction in fecal coliform bacteria may take place inside the septic tank, it is the removal of pathogenic bacteria and viruses that is the concern of health officials. In general, pathogenic microorganisms are quite host specific and do not survive very long apart from the host. Because viruses are charged particles and respond to flocculants, most become attached to septic tank solids and remain in the tank sludge (1).

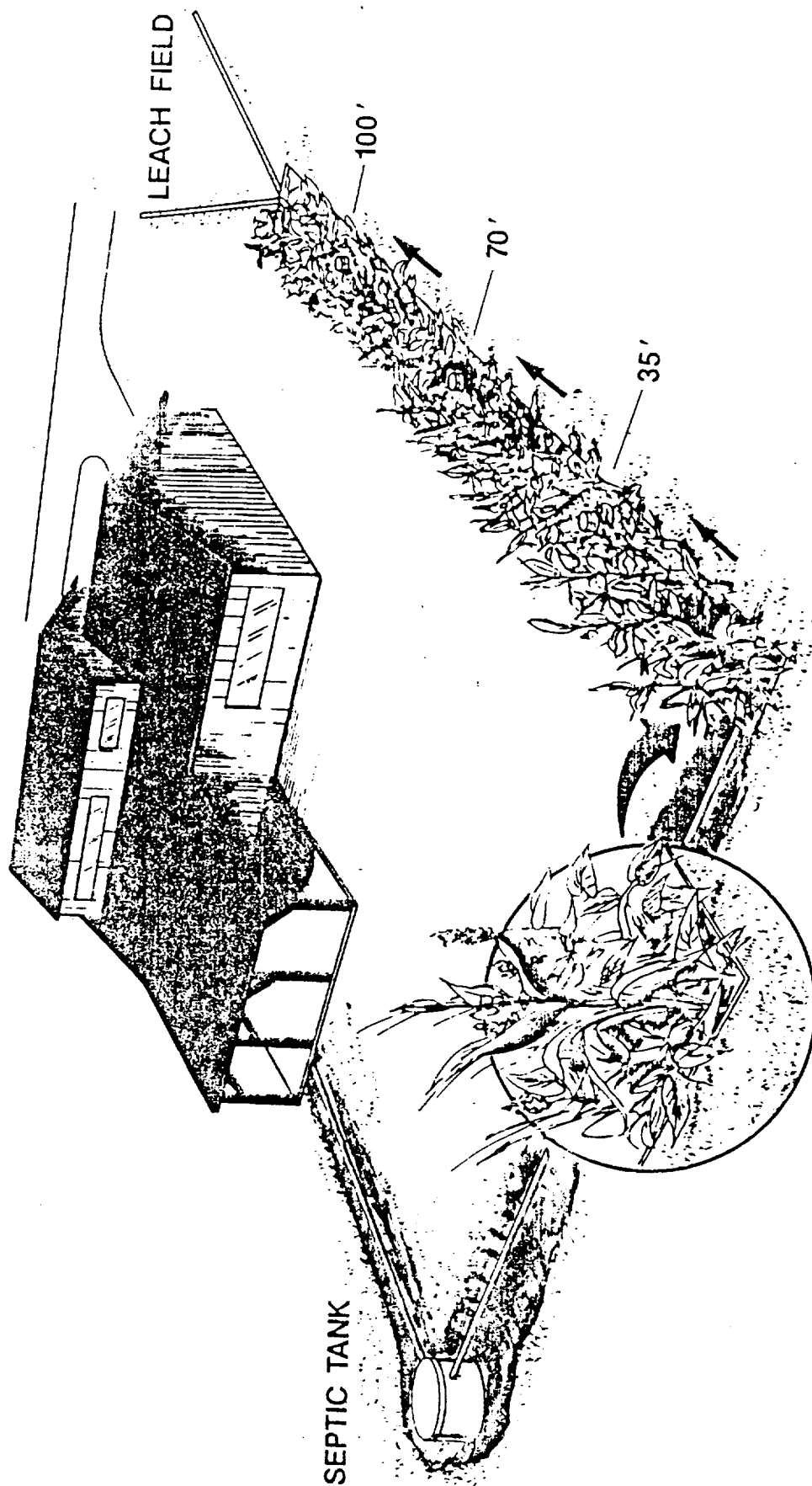
Problems with septic tank systems are not normally associated with properly installed, sealed tanks, but with the leach field component of the system. To make the septic tank system more versatile and acceptable in most climates and soil conditions, an aquatic plant/microbial filter can be

used to replace the leach field (3). The use of natural biological processes for treating various types of wastewater has been developed by NASA at the National Space Technology Laboratories (NSTL) during the past 15 years (4 - 10). An aquatic plant filter constructed of washed gravel receives the partially treated, odorous discharge from the septic tank and continues the treatment process. It is important that the filter is maintained at such a depth that the anaerobic septic tank effluent is converted to aerobic conditions and maintained throughout the filter. Once aerobic conditions are achieved, odor removal and water clearing will begin. At this point in the rock/plant filter, protozoa begin to grow. These large microorganisms feed on bacteria and other microscopic life and are essential in the final purification process in which natural processes are used to remove coliform and other bacteria. Soil conditions determine whether the filter should be lined with a layer of clay or a plastic sheet liner. Under certain conditions a liner may not be required. The purity of the filter effluent is determined by the length and depth of the filter in addition to the retention time.

There are more than ten single-home septic tank/rock/plant sewage treatment systems presently in operation in Mississippi. These systems are located in the Picayune, Hattiesburg and Philadelphia areas. The systems in the Philadelphia area are on the Choctaw Indian Reservation. These single home units are designed in accordance with the sketch shown in Figure 1. Approximately 400 ft² (37.2 m²) of surface area are recommended for the single-home/rock/plant filter and approximately 20 ft (6 m) of 4 in (10.2 cm) perforated leach field tubing used to disperse the highly treated rock/plant filter effluent beneath the soil.

FIGURE 1

ARTIFICIAL MARSH SYSTEM FOR TREATING DISCHARGE FROM SEPTIC TANKS



The single home system used to obtain the design parameters is located in Picayune, Mississippi. A 70 foot (21.3 m) section of this rock/plant filter was monitored for several years with the average data shown in Table 1.

A septic tank/rock/plant sewage treatment system for treating wastewater from a radio station at Hattiesburg, MS began operation in May 1988. A 12,000 gpd (45.4 m³) septic tank/rock/plant system is also in operation at Pearlington, Mississippi, located on the Mississippi Gulf Coast. This system treats the wastewater from a mobile home park, Figure 2. There are also over 20 operational single home septic tank/rock/plant sewage treatment systems in Louisiana with an additional 20 approved by the Louisiana Health Department for installation throughout the state.

SCIENTIFIC BASIS FOR USING AQUATIC PLANTS IN WASTEWATER TREATMENT

Biologically, the aquatic plant systems are far more diverse than present day mechanical treatment systems. Oxidation ditches and other types of extended aeration treatment systems use energy intensive mechanical aerators to supply large amounts of oxygen for growing aerobic microorganisms which treat the wastewater.

The scientific basis for waste treatment in a vascular aquatic plant system is the cooperative growth of both the plants and the microorganisms associated with the plants. A major part of the treatment process for degradation of organics is attributed to the microorganisms living on and around the plant root systems.

Once microorganisms are established on aquatic plant roots, in most cases they form a symbiotic relationship with the higher plants. This relationship normally produces a synergistic effect resulting in increased degradation rates and removal of organic chemicals from the wastewater surrounding the plant root systems. Products of the microbial degradation

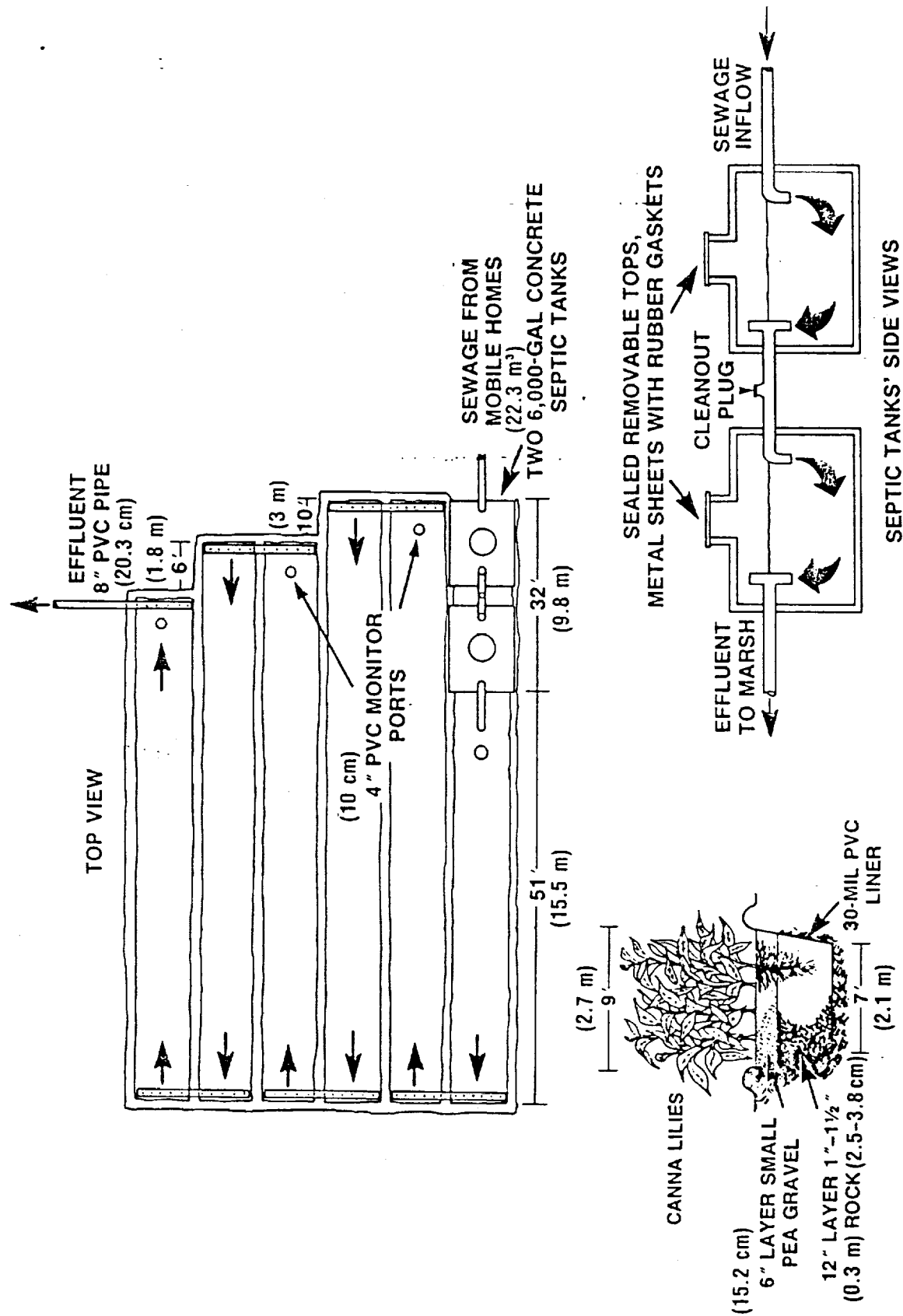
TABLE 1. SINGLE HOME WASTEWATER TREATMENT SYSTEM USING A ROCK/PLANT FILTER TO TREAT SEPTIC TANK EFFLUENT.*

<u>PARAMETER</u>	<u>FILTER INFLUENT SEPTIC TANK EFFLUENT</u>	<u>AFTER 35 FT (10.7 M)</u>	<u>AFTER 70 FT (21.3 M)</u>
BOD ₅ , mg/L	100	32	10
NH ₃ -N, mg/L	28	24	7
Fecal coliform colonies/100 mL	600,000	72,000	19,000

*Data from a 3.28 ft (1 m) wide x 70 ft (21.3 m) long filter with a 12 in (0.3 m) wastewater depth containing 4 in - 6 in (10 - 15 cm) of gravel on top. Elephant ears and calla lilies were the dominant plants in this system. From this data, a 4 ft (1.2 m) wide x 100 ft (30.5 m) long filter system is recommended for achieving tertiary level treatment of septic tank effluent from single homes, 2 - 3 people per home.

FIGURE 2

SEPTIC TANK/PLANT WASTEWATER TREATMENT SYSTEM FOR SUNRISE HAVEN MOBILE HOME PARK, PEARLINGTON, MISSISSIPPI



of the organics are absorbed and utilized as a food source by the plants along with N, P, K and other minerals. Microorganisms also use metabolites released through plant roots as a food source. By each using the others waste products, a reaction is sustained in favor of rapid removal of organics from wastewater. Electrical charges associated with aquatic plant root hairs also react with opposite charges on colloidal particles such as suspended solids causing them to adhere to the plant roots where they are removed from the wastewater stream and slowly digested and assimilated by the plant and microorganisms. Aquatic plants have the ability to translocate O_2 from the upper leaf areas into the roots producing an aerobic zone around the roots which is desirable in domestic sewage treatment.

TEMPERATURE EFFECTS ON THE SEPTIC TANK ROCK/PLANT MARSH TREATMENT SYSTEM

Studies conducted in the state of Washington, Canada and Alaska have indicated that septic tank systems perform satisfactorily during the winter months in these cold climates. Experiments at Fairbanks and Anchorage, Alaska demonstrated that the large amount of heat provided to the septic tank by wastewater from the residence appears to be a significant factor in maintaining the disposal system at an operable temperature (2). Cold-tolerant plants such as bulrushes and cattails must be used when installing septic tank/rock/plant wastewater treatment systems in cold climates. Studies in Anchorage also demonstrated the better insulating properties of concrete tanks over steel tanks.

Temperature studies in the states of Washington and Wisconsin where the septic tank mound system is used indicate that the rock/plant system could possibly be used in lieu of the mound system and in most cases reduce the cost by eliminating the need for the pumping chamber used in a large number of mound systems. The mound system is essentially an elevated soil absorption system (1).

SUMMARY

1. Single-home septic tank studies to date indicate that septic tank effluent from single homes can be treated to advanced secondary levels or greater by using a 400 ft² (37.2 m²) washed gravel filter. This filter should be 1.0 to 1.5 ft (.3 - .46 m) D with the wastewater level maintained approximately 6 in (15.2 cm) below the rock surface. When aesthetic plants such as calla lily (Zantedeschia aethiopica), canna lily (Canna flaccida) elephant ears (Colocasia esculenta), water iris (Iris pseudacorus) and ginger lily (Hedychium coronarium) are planted in the rock filter, their roots will penetrate into the wastewater level adding oxygen and increasing biological activity. If a point source discharge is undesirable, approximate 20 ft (6 m) of 4 in (10.3 cm) perforated leach field tubing should be used to disperse the highly treated rock/plant filter effluent beneath the soil.
2. Large septic tanks are being used in some small towns and communities in lieu of open sewage lagoons. This type of wastewater treatment system has many advantages over open lagoon systems. Tanks can be installed underground in many different locations throughout the collection area, taking advantage of the land elevations. All of the tanks can then be connected to drain pipes which take the effluent to one or more rock/plant filters for treatment. The size of the rock/plant filter system will be dictated by the volume of septic tank effluent and the level of treatment desired. When these systems are properly installed, there will be no open-air exposure to sewage before treatment has been accomplished. If, at any time after start-up of the

system, odor is detected then some component of the system was improperly installed.

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